Pulleys Exam Questions

Q1

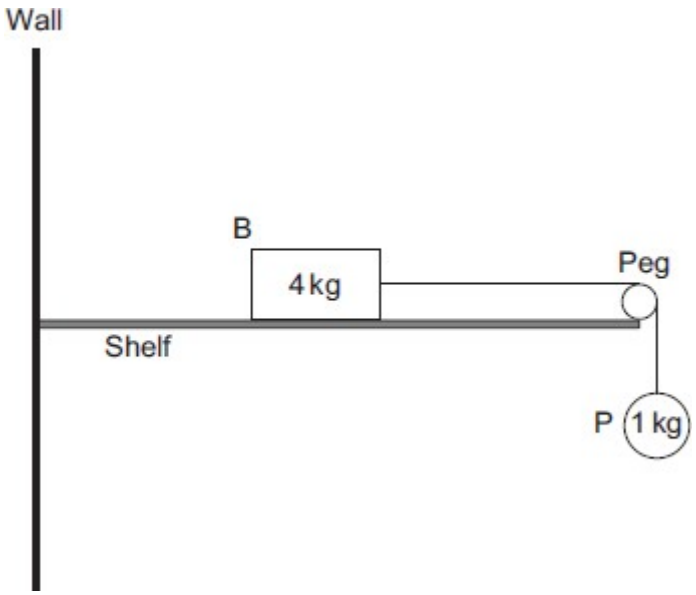
In this question, use $g = 10\,\text{ms}^{-2}$

A box, B, of mass 4 kg lies at rest on a fixed rough horizontal shelf.

One end of a light string is connected to B.

The string passes over a smooth peg, attached to the end of the shelf.

The other end of the string is connected to particle, P, of mass 1 kg, which hangs freely below the shelf as shown in the diagram below.



B is initially held at rest with the string taut.

B is then released.

B and P both move with constant acceleration $a\,\text{ms}^{-2}$

As B moves across the shelf it experiences a **total** resistance force of 5 N

(a) State one type of force that would be included in the total resistance force.

_____

_____

_____

(1)

(b) Show that $a = 1$

(4)

(c) When B has moved forward exactly 20 cm the string breaks.

Find how much further B travels before coming to rest.

(4)

(d) State one assumption **you** have made when finding your solutions in parts (b) or (c).

(1)

(Total 10 marks)

Q2.

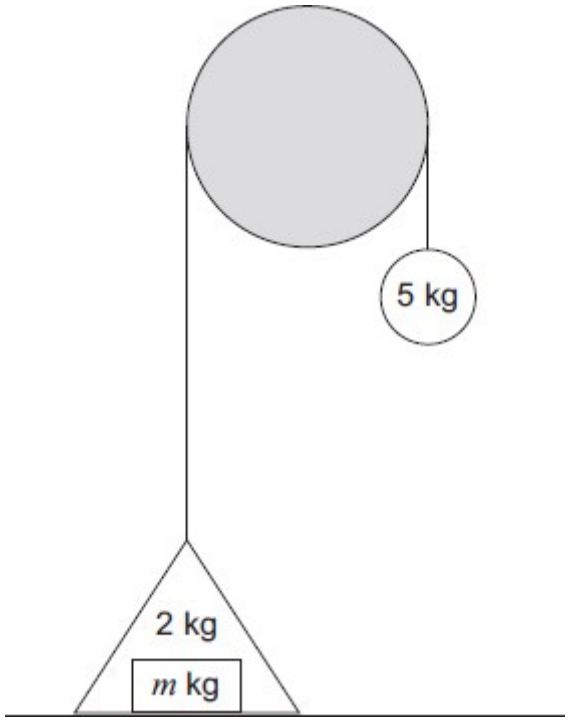
A simple lifting mechanism comprises a light inextensible wire which is passed over a smooth fixed pulley.

One end of the wire is attached to a rigid triangular container of mass 2 kg, which rests on horizontal ground.

A load of m kg is placed in the container.

The other end of the wire is attached to a particle of mass 5 kg, which hangs vertically downwards.

The mechanism is initially held at rest as shown in the diagram below.



The mechanism is released from rest, and the container begins to move upwards with

acceleration a m s^{-2}

The wire remains taut throughout the motion.

(a) Show that

$$a = \left(\frac{3-m}{m+7}\right) g$$

(4)

(b) State the range of possible values of m.

(1)

(c) **In this question use g = 9.8 m s^{-2}**

The load reaches a height of 2 metres above the ground 1 second after it is released.

Find the mass of the load.

(4)

(d) Ignoring air resistance, describe **one** assumption you have made in your model.

(1)
(Total 10 marks)

Mark schemes

Q1.

	Marking Instructions	AO	Marks	Typical Solution
(a)	States either friction or air resistance or both but no incorrect forces.	3.3	B1	Friction

(b)	Uses $F = ma$ to form a three term equation modelling the motion of P	3.3	M1	$10 - T = 1 \times a$ $T - 5 = 4 \times a$ $5 = 5a$ $a = 1$
	Uses $F = ma$ to form a three term equation modelling the motion of B	3.3	M1	
	Obtains two correct equations	1.1b	A1	
	Completes a rigorous argument to show that $a = 1$	2.1	R1	

(c)	Uses appropriate suvat equation with given values to find v or v^2	3.3	M1	$v^2 = 0 + 2 \times 1 \times 0.2 = 0.4$
	Uses $F = ma$ to find acceleration of B after string breaks	3.4	M1	$-5 = 4a$ $a = -1.25$
	Obtains $a = -1.25$	1.1b	A1	$0^2 = 0.4 + (2)(-1.25)s$
	Uses appropriate suvat equation to obtain 0.16 m. Must include units.	1.1b	A1	$s = 0.16\,\text{m}$ $s = 0.2\,\text{m}$, to 1 sf

(d)	States a valid assumption Accept: • No air resistance to motion of P • string remains parallel to table • B does not reach end of table before it stops • P does not hit floor before string breaks	3.5b	E1	String is inextensible

Total 10 marks

Q2.

	Marking Instructions	AO	Marks	Typical Solution
(a)	Models the motion of the container and load with at least one side of the equation correct.	3.3	M1	$T-(m+2)g=(m+2)a$
	Forms fully correct equation	1.1b	A1	
	Forms fully correct equation for particle	3.3	B1	$5g-T=5a$
	Completes a rigorous argument by eliminating T and rearranging to express a in terms of m. AG	2.1	R1	$5g-(m+2)g=(5+2+m)a$ $(3-m)g=(7+m)a$ $\therefore a=\left(\frac{3-m}{m+7}\right)g$
	Subtotal		**4**	

(b)	Deduces correct limits Condone $0 \leq m < 3$	2.2a	B1	$0 < m < 3$
	Subtotal		**1**	

(c)	Uses appropriate constant acceleration equation to find the acceleration	3.4	M1	$s=ut+\frac{1}{2}at^2$ Using s =2, u = 0 and t = 1
	Calculates correct value for a	1.1b	A1	$a=4$
	Forms equation for a in terms of m using their a value	3.4	M1	$4=\left(\frac{3-m}{m+7}\right)g$
	Solves to find m. AWRT 0.10 Condone 0.1	3.2a	A1	$m=\frac{3g-28}{4+g}=0.10$ kg
	Subtotal		**4**	

(d)	Describes any valid assumption not related to those assumptions already stated in the question. Eg The particle is at least 2m above the ground Eg The particle does not collide with the load	3.5b	E1	I assumed that the top of the container does not reach the pulley
	Subtotal		**1**	

Question Total		**10**	